IS 5477 (Part 2) : 2020

भारतीय मानक
Indian Standard

जलाशयों की क्षमता निर्धारित करने के तरीके

भाग 2 अप्रयुक्त भंडारण

(दूसरा पुनरीक्षण)

Methods for Fixing the Capacities of Reservoirs

Part 2 Dead Storage

(*Second Revision*)

ICS 93.160

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July 2020 **Price Group 7**

Reservoirs and Lakes Sectional Committee, WRD 10

FOREWORD

This Indian Standard (Part 2) (Second Revision) was adopted by the Bureau of Indian Standards on recommendation of the Reservoirs and Lakes Sectional Committee and approval of the Water Resources Division Council.

By providing extra storage volume in the reservoir for sediment accumulation, in addition to the live storage, it is ensured that the live storage, although it contains sediment, will function at full efficiency for an assigned number of years. This volume of storage (in the fixation of which the minimum draw down level is also a major criterion in case of power projects) is referred to as the dead storage and is equivalent to the volume of sediment expected to be deposited in the reservoir during the designed life of the structure.

The distribution pattern of sediments in the entire depth of a reservoir depends on many factors, such as slope of the valley, length of reservoir, sediment and capacity inflow ratio constriction in the reservoir, particle size of the suspended but the reservoir operation has an important control over other factors. However, knowledge of this pattern is essential, especially, in developing areas in order to have an idea about the formation of delta and the recreational spots and the consequent increase in back water levels after the reservoir comes into operation.

This standard (Part 2) was first published in 1969 and subsequently revised in 1994. This revision is being done to incorporate the latest knowledge in this field. In this revision, example for the usage of 'empirical area reduction method' to calculate the probable sediment deposition in reservoirs has been modified.

This Indian Standard is published in four parts. The other parts in this series are:

Part 1 General requirements

Part 3 Live storage

Part 4 Surcharge storage

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHODS FOR FIXING THE CAPACITIES OF RESERVOIRS

PART 2 DEAD STORAGE

(*Second Revision*)

1 SCOPE

This standard (Part 2) covers methods for computing the sediment yield and for predicting the probable sediment distribution in the reservoir below normal (full) reservoir level (F.R.L.).

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
4410 (Part 6) : 1983	Glossary of terms relating to river valley projects: Part 6 Reservoirs (*first revision*)
4890 : 1968	Methods for measurement of suspended sediment in open channels
12182 : 1987	Guidelines for determination of effects of sedimentation in planning and performance of reservoirs

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4410 (Part 6) : 1983 shall apply.

4 MEASUREMENT OF SEDIMENT YIELDS

4.1 The sediment yield in a reservoir may be estimated by any one of the following two methods:

a) Sedimentation surveys of reservoirs with similar catchment characteristics, or

b) Sediment load measurements of the stream.

4.2 Reservoir Sedimentation Survey

4.2.1 The sediment yield from the catchment is determined by measuring the accumulated sediment in a reservoir for a known period, by means of echo sounders and other electronic devices since the normal sounding operations give erroneous results in large depths. The volume of sediment accumulated in a reservoir is computed as the difference between the present reservoir capacity and the original capacity after the completion of the dam. The unit weight of deposit is determined in the laboratory from the representative undisturbed samples or by field determination using a calibrated density probe developed for this purpose. The total sediment volume is then converted to dry weight of sediment on the basis of average unit weight of deposits. The tota1 sediment yield for the period of record covered by the survey will then be equal to the total weight of the sediment deposited in the reservoir plus that which has passed out of the reservoir based on the trap efficiency. In this way, reliable records may be readily and economically obtained on long-term basis.

4.2.2 The density of deposited sediment varies with the composition of the deposits, location of the deposit within the reservoir, the flocculation characteristics of clay content and water, the age of deposit, etc. For coarse material (0.0625 mm and above) variation of density with location and age may be unimportant. Normally a time and space average density of deposited materials applicable for the period under study is required for finding the overall volume of deposits. For this purpose the trapped sediment for the period under study would have to be classified in different fractions.

Most of the sediment escaping from getting deposited into the reservoir should be from the silt and clay fractions. In some special cases local estimates of densities at points in the reservoir may be required instead of average density over the whole reservoir.

4.2.3 The trap efficiency mainly depends upon the capacity-inflow ratio but may vary with location of outlets and reservoir operating procedure. Computation of reservoir trap efficiency may be made using trap efficiency curves, such as those developed by Brune and Churchill (*see* IS 12182).

4.2.4 The sedimentation rates observed in adjacent reservoirs also serve as guide while designing dead storage capacity for a new reservoir. The rate of sedimentation observed in similar reservoirs and/or adjacent basin should be suitably modified keeping in view the density of deposited material, trap efficiency and sediment yield from the catchment.

4.3 Sediment Load Measurements

Periodic samples from the stream should be taken at various discharges along with the stream gauging observations and the suspended sediment concentration should be measured as detailed in IS 4890. A sediment rating curve which is a plot of sediment concentration against the discharge, is then prepared and is used in conjunction with stage duration curve (or flow duration) based on uniformly spaced daily or shorter time units data in case of smaller river basins to assess sediment load. For convenience, the correlation between sediment concentration against discharge may be altered in relation to sediment load against run-off for calculating sediment yield. Where observed stage/flow data is available for only shorter periods, these have to be suitably extended with the help of longer data on rainfall. The sediment discharge rating curves may also be prepared from hydraulic considerations using sediment load formula, that is, modified Einstein's procedure.

4.3.1 The bed load measurement is preferable. However, where it is not possible, it may be estimated using analytical methods based on sampled data or as a percentage of suspended load (generally ranging from 10 to 20 percent). This should be added to the suspended load to get the total sediment load.

5 PREDICTING SEDIMENT DISTRIBUTION

5.1 The sediment entering into a storage reservoir gets deposited progressively with the passage of time and thereby reduces the dead as well as live storage capacity of the reservoir. This causes the bed level near the dam to rise and the raised bed level is termed as new zero- elevation. It is, therefore, necessary to assess the revised areas and capacities at various reservoir elevations that would be available in future and could be used in simulation studies to test the reservoir performance and also the new zero-elevation.

The following procedure may be adopted for fixing the dead storage level and sill levels of the outlets:

a) The distribution of the estimated sediment load for the feasible service time of the reservoir should be carried out and new zero-elevations should be determined, and
b) The minimum draw down level is fixed a little above the new zero-elevation computed in **5.1** (a) above. When other considerations like command area elevation, providing extra head for power generation prevail, this elevation is fixed higher than one of these.

5.2 Several methods are in use for predicting sediment distribution in reservoirs for design purposes. Either the empirical area reduction method or the area increment method may be used.

5.2.1 *Empirical Area Reduction Method*

This method is based on the analysis of data of sediment distribution. In this method, reservoirs are classified into four types, namely:

a) gorge,
b) hill,
c) flood plain-foot hill, and
d) lake.

Based on the ratio of the reservoir capacity to the reservoir depth plotted on a log-log scale (*see* Fig. 1). Fig 2 and Fig. 3 give the sediment distribution area design curves for each type of these reservoirs. The equation for the design curve used is:

$$A_p = Cp^m (1 - p)^n \; . \; . \; . \; ... \qquad (1)$$

Where,

A_p = a non-dimensional relative area at relative distance 'p' above the stream bed, and

C, m and n = non-dimensional constants which have been fixed depending on the type of reservoir.

5.2.1.1 These curves are used to work out the probable sediment deposition in the reservoir at different depths. This method is more reliable than the area increment method. An example of the usage of this method is given in Annex A.

5.2.2 *Area Increment Method*

The basic assumption in this method is that the sediment deposition in the reservoir may be approximated by reducing the reservoir area at each reservoir elevation by a fixed amount. Successive approximations are made. Average end area (or prismoidal formula) is used to compute the reservoir capacities on the basis of reduced surface areas until the total reservoir capacity below the full reservoir level is the same as the predetermined capacity obtained by subtracting the sediment accumulation with time from the original capacity.

The basic equation in this method is:

$$V_s = A_o (H - h_o) + V_o \; . \; . \; . \; . \; . \; . \; . \qquad (2)$$

Where,

V_s = the sediment volume to be distributed in the reservoir in hectare metres,

A_o = the area correction factor in hectares which is original reservoir the new zero elevation of the reservoir,

H= the reservoir depth below full reservoir level (F.R.L.) in metres,

h_o = the depth in metres to which the reservoir is completely filled with sediment, and

V_o = the sediment volume below new zero elevation in hectare, metres.

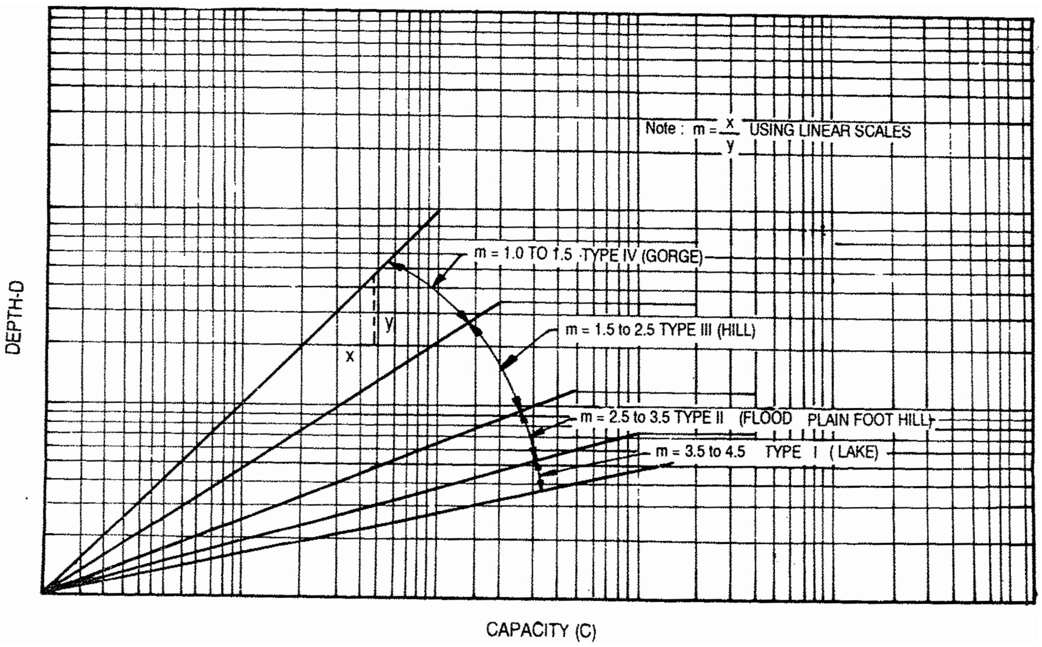

FIG. 1 CLASSIFICATION OF RESERVOIR DEPTH VERSUS CAPACITY RELATIONSHIP

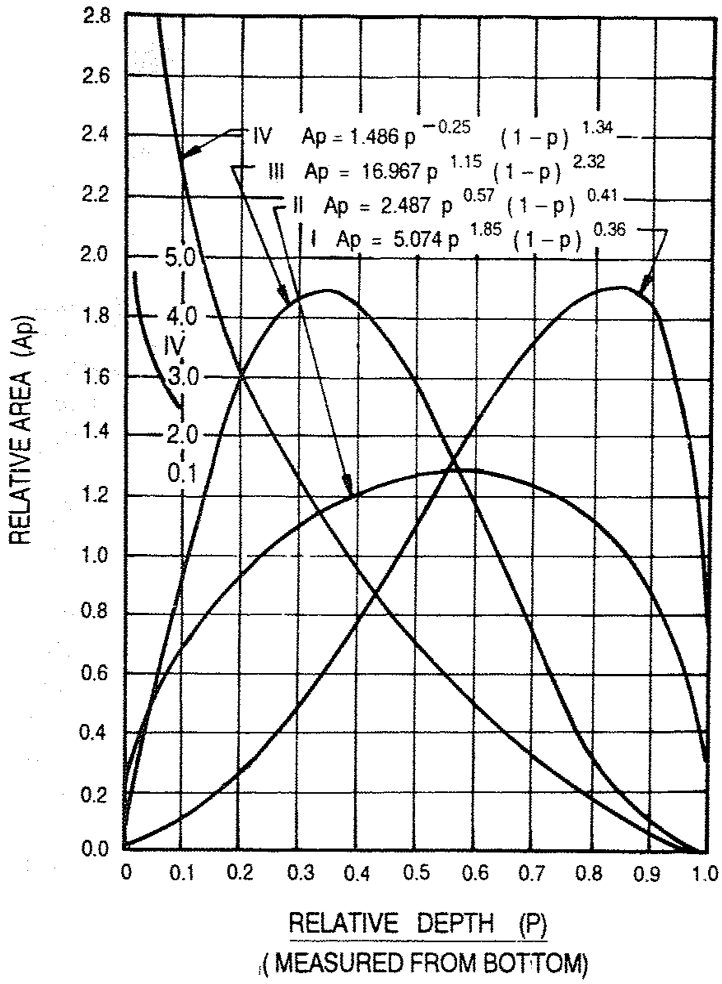

FIG. 2 SEDIMENT DISTRIBUTION — AREA DESIGN CURVES (BASED ON RESERVOIR STORAGE CURVES)

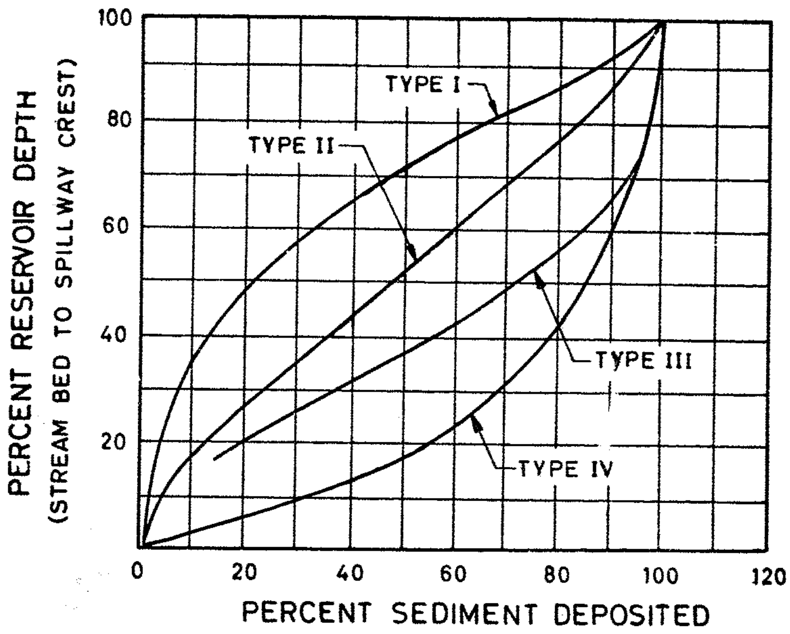

FIG. 3 TYPES CURVES OF PERCENT SEDIMENT DEPOSITED VERSUS PERCENT RESERVOIR DEPTH BASE ON ACTUAL OCCURRENCES

5.2.2.1 In other words, the equation mathematically expresses that the total sediment volume V_s, consists of two parts, namely:

a) the portion which is uniformly distributed vertically over the height H - H_o, with an area equal to A_o, and
b) the portion V_o, below the new zero elevation of the reservoir.

5.2.2.2 An example of the usage of this method is given in Annex B.

NOTE — The applicability of this method decreases with the increase in the ratio of $\left[\frac{\text{sediment deposit}}{\text{reservoir capacity}}\right]$. If the hundred years sediment, accumulation exceeds 15 percent of the original capacity, a more exact method should be applied.

5.2.3 *Moody's Method to Find New Zero Elevation*

This method is used to determine the new zero elevation directly without trial and error process. Two parameters *f(p)* and *f' (p)* as explained below are made use of:

$$f(p) = \frac{1\text{-V}(\text{p})}{\text{a}(\text{p})}$$

$$f'(p) = \frac{\text{S-V}(\text{pH})}{\text{H}A(\text{pH})}$$

Where,

$f(p)$ = a function of the relative depth of reservoir for one of the four types of theoretical design curves,

V (p) = relative volume at a given elevation,

a (p) = relative area at a given elevation,

f (p) = a function of the relative depth of reservoir for a particular reservoir and its anticipated sediment storage,

S = total sediment in the reservoir in hectare metres,

V(*p*H) = reservoir capacity at a given elevation in hectare metres,

H = the total depth of reservoir for normal water surface in metres, and

A(*p*H) = reservoir area at a given elevation in hectares.

5.2.3.1 Table 1 gives the value of the function *f(p)* for the four types of reservoirs (*see* **5.2.1**) and Fig. 4 shows the plotting of *f(p)* against relative reservoir depth, *p*, for the four types of reservoirs of the empirical area method (*see* **5.2.1**) and also for the area increment method (*see* **5.2.2**).

5.2.3.2 To determine the new zero elevation, *f(p)* should equal *f(p)*. This is done graphically by plotting the values of *f(p)* and superposing this over the relevant *f(p)* curve. The intersection gives the relative depth of P_0 reservoir at new zero, elevation after sedimentation. New zero-elevation may be computed by adding the product $P_0 \times H$ to the original stream bed elevation. After arriving at the new zero elevation, either empirical area method (*see* **5.2.1**) or the area increment method (*see* **5.2.2**) is used.

5.2.3.3 An example to find out the new zero elevation is given in Annex C.

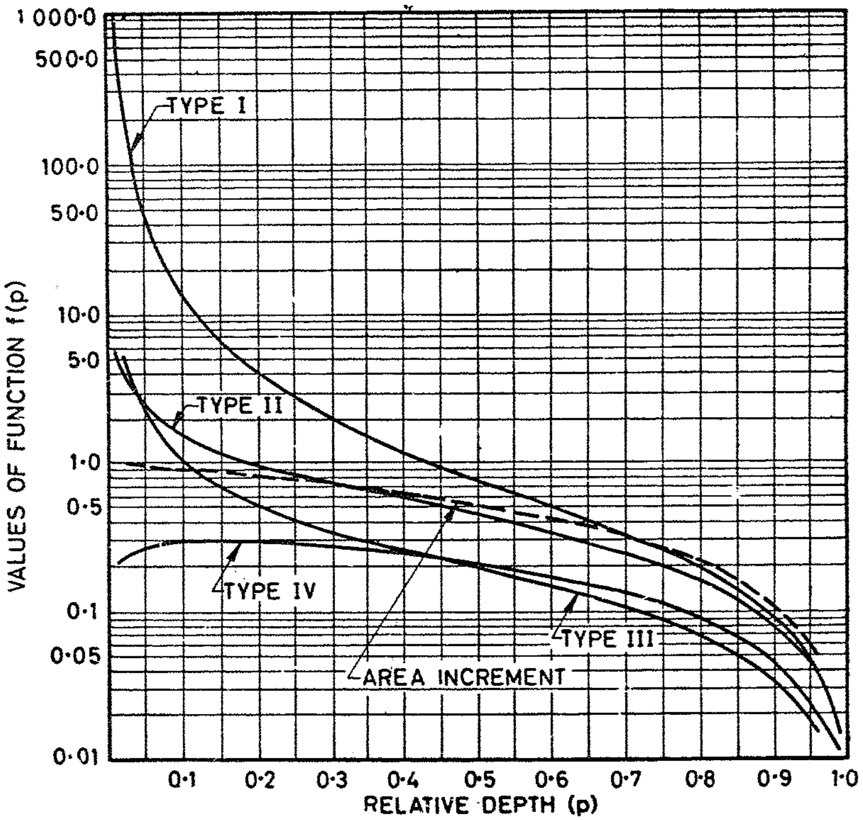

FIG. 4 CURVES OF DETERMINE THE DEPTH OF SEEDIMENT IN THE RESERVOIR

Table 1 Values of the Function *f(p)* for the Four Types of Reservoirs

(*Clause* 5.2.3.1)

P	Type			
	I	II	III	IV
(1)	(2)	(3)	(4)	(5)
0				
0.01	996.7	10.568	12.03	0.202 3
0.02	277.5	3.758	5.544	0.239 0
0.05	51.49	2.233	2.057	0.279 6
0.1	14.53	1.495	1.013	0.291 1
0.15	6.971	1.169	0.682 1	0.293 2
0.2	4.145	0.970 6	0.518 0	0.287 8
0.25	2.766	0.829 9	0.417 8	0.278 1
0.3	1.900	0.721 2	0.348 6	0.255 6
0.35	1.495	0.632 3	0.296 8	0.251 8
0.4	1.109	0.556 5	0.233 3	0.236 5
0.45	0.907 6	0.490 0	0.221 2	0.219 7
0.5	0.726 7	0.430 3	0.191 7	0.201 0
0.55	0.586 0	0.376 8	0.168 7	0.182 6
0.6	0.473 2	0.325 3	0.142 2	0.163 7
0.65	0.380 5	0.278 0	0.120 7	0.144 3
0.7	0.302 6	0.233 3	0.100 8	0.124 5
0.75	0.235 9	0.190 7	0.082 04	0.104 4
0.8	0.177 7	0.150 0	0.064 28	0.083 97
0.85	0.120 2	0.110 7	0.047 31	0.063 30
0.9	0.080 11	0.072 76	0.031 01	0.042 39
0.95	0.058 30	0.026 98	0.015 27	0.021 23
0.98	0.014 94	0.014 25	0.006 057	0.008 534
0.99	0.007 411	0.007 109	0.003 020	0.002 470
1.0	0.00	0.00	0.00	0.00

ANNEX A

(*Clause* 5.2.1.1)

EMPIRICAL AREA REDUCTION METHOD

A-1 DATA

The data given are as follows:

a) Original Elevation = Area capacity curves,
b) Annual sediment inflow = 37.00 hectare meters,
c) Bed elevation = 1265.00 m,
d) Normal water surface elevation (F.R.L.) = 1302.50 m,
e) Spillway crest = 1302.50 m, and
f) Period of sedimentation 100 years (total sediment volume for the period = 3 700 hectare metres).

A-2 PROCEDURE

A-2.1 Referring to Table 2, the data given in column 1, 2 and 3 are from original elevation area capacity curves. The relative depth ratio at different elevations [ratio of depth at an elevation above stream bed to the total depth of spillway crest (or F.R.L.) above stream bed] is entered in column 4. Reservoir depth is plotted as ordinate against reservoir capacity as abscissa at different elevations on a log-log paper. A line is drawn through the plotted points. Reciprocal of the slope of the line will give the value of 'm' by which reservoir type is selected (*see* Fig. 1). In this case, it is Type II (*see* Fig. 5). The plot may sometimes indicate a curve having different slopes in different parts. In such cases, the reservoir may be classified into the type in which major portion of the sediment would deposit.

A-2.2 A_p in column 5 is obtained from the relevant curve (corresponding to Type II reservoir) of Fig. 2. The new zero-elevation in the reservoir, up to which the sediment will completely fill the reservoir, is found by trial and error. Zero elevation is assumed, which in this case is 1 277.2 m. Surface area corresponding to this elevation is 124.966 hectares. A_p at this elevation is 1.116 (*see* Fig. 2). Find out 'K', the ratio of original area at assumed new zero-elevation (column 2) to the corresponding A_p value (column 5).

$$K = \frac{124.966}{1.116} = 111.98$$

A-2.2.1 Column 6 is 'K' multiplied A_p values at each succeeding incremental elevation above assumed new zero-elevation, which gives sediment area.

A-2.2.2 Column 7 is the cumulative sum of the increment of sediment volume in each segment computed by either of the following methods:

$$V - \frac{h}{2}(A_1 + A_2) \quad \ldots$$

Average end area method or as

$$V - \frac{h}{3}(A_1 + A_2 - \sqrt{A_1 + A_2}) \quad \ldots$$

Prizmoidal formula (weighted area method)

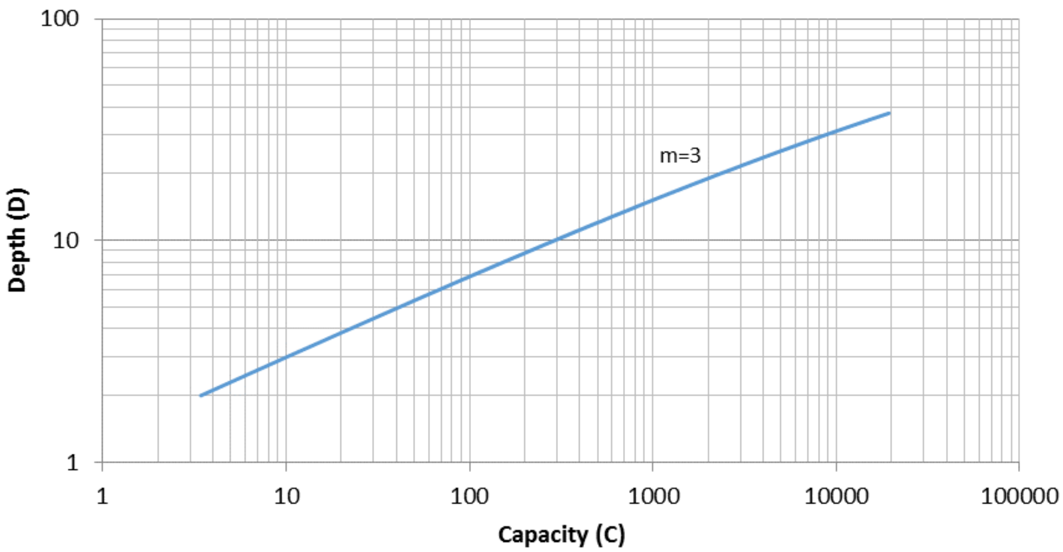

FIG. 5 CCURVE TO DETERMINE VALUE OF 'M'

Where,

h = Height of the segment,

A_1 and A_2 = Areas at the ends of segment, and

V = Volume of the segment.

A-2.2.3 Sum of column 7 gives the sediment volume of 3 665.661 Ha.m (in this case calculated using prizmoidal formula) which is nearly equal to the computed sediment volume of 3 700.00 Ha.m. Hence, the zero-elevation assumed is correct. If the values do not tally, further trials have to be made till the sediment values differ by not more than one percent column 8 gives the sediment accumulation volume in hectare meters. Revised areas in column 9 are obtained by subtracting values in column 6 from column 2. Revised capacity in column 10 is obtained by subtracting values in column 8 from column 3.

Table 2 Sediment Deposition Computation by Empirical Area Reduction Method

(*Clause* A-2.1)

Elevation (m)	**Original** Area (Ha)	**Original** Cum. Capacity (Ha. m)	**Relative Depth Ratio**	**Ap (Type-II)**	**Sediment** Area (Ha)	**Sediment** Volume (Ha. m)	**Accumulated Sediment Volume (Ha. m)**	**Revised** Area (Ha)	**Revised** Capacity (Ha. m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1265	0	0	0.000	0.000	—	—	—	—	—
1266	1.43	0.54	0.027	0.312	—	—	—	—	—
1267	4.6	3.43	0.053	0.457	—	—	—	—	—
1268	9.23	10.23	0.080	0.570	—	—	—	—	—
1269	15.28	22.37	0.107	0.663	—	—	—	—	—
1270	22.75	41.26	0.133	0.744	—	—	—	—	—
1271	31.7	68.36	0.160	0.815	—	—	—	—	—
1272	42.19	105.17	0.187	0.878	—	—	—	—	—
1273	54.29	153.27	0.213	0.934	—	—	—	—	—
1274	68.08	214.3	0.240	0.985	—	—	—	—	—
1275	83.66	290.01	0.267	1.031	—	—	—	—	—
1276	101.15	382.24	0.293	1.072	—	—	—	—	—
1277	120.64	492.95	0.320	1.109	—	—	—	—	—
1277.20	124.966	519.202	0.325	1.116	124.966	0.000	519.202	0.000	0.000
1278	142.27	624.21	0.347	1.142	127.877	101.135	620.337	14.393	3.873
1279	166.17	778.22	0.373	1.171	131.135	129.503	749.840	35.035	28.380
1280	192.48	957.32	0.400	1.196	133.984	132.557	882.397	58.496	74.923
1281	221.35	1163.99	0.427	1.218	136.438	135.209	1017.606	84.912	146.384
1282	252.93	1400.87	0.453	1.237	138.504	137.470	1155.076	114.426	245.794
1283	287.4	1670.76	0.480	1.252	140.187	139.345	1294.420	147.213	376.340
1284	324.94	1976.64	0.507	1.263	141.487	140.836	1435.257	183.453	541.383
1285	365.74	2321.66	0.533	1.272	142.403	141.945	1577.202	223.337	744.458
1286	410	2709.2	0.560	1.276	142.929	142.666	1719.868	267.071	989.332
1287	457.94	3142.81	0.587	1.277	143.055	142.992	1862.860	314.885	1279.950
1288	509.78	3626.29	0.613	1.275	142.769	142.912	2005.772	367.011	1620.518
1289	565.77	4163.65	0.640	1.268	142.051	142.410	2148.182	423.719	2015.468
1290	626.15	4759.17	0.667	1.258	140.879	141.465	2289.647	485.271	2469.523
1291	691.19	5417.37	0.693	1.243	139.222	140.050	2429.696	551.968	2987.674
1292	761.19	6143.06	0.720	1.224	137.042	138.130	2567.827	624.148	3575.233
1293	836.43	6941.34	0.747	1.199	134.287	135.662	2703.489	702.143	4237.851
1294	917.24	7817.61	0.773	1.169	130.893	132.586	2836.075	786.347	4981.535

Table 2 *(Concluded)*

Elevation (m)	Original		Relative Depth Ratio	Ap (Type-II)	Sediment		Accumulated Sediment Volume (Ha. m)	Revised	
	Area (Ha)	Cum. Capacity (Ha. m)			Area (Ha)	Volume (Ha. m)		Area (Ha)	Capacity (Ha. m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1295	1003.95	8777.6	0.800	1.132	126.771	128.827	2964.902	877.179	5812.698
1296	1096.92	9827.39	0.827	1.088	121.803	124.279	3089.181	975.117	6738.209
1297	1196.51	10973.42	0.853	1.034	115.817	118.797	3207.978	1080.693	7765.442
1298	1303.12	12222.5	0.880	0.969	108.557	112.167	3320.145	1194.563	8902.355
1299	1417.16	13581.86	0.907	0.889	99.609	104.051	3424.196	1317.551	10157.664
1300	1539.08	15059.15	0.933	0.788	88.219	93.856	3518.053	1450.861	11541.097
1301	1669.34	16662.48	0.960	0.649	72.707	80.338	3598.391	1596.633	13064.089
1302	1808.41	18400.42	0.987	0.420	47.070	59.426	3657.816	1761.340	14742.604
1302.50	1882	19330	1.000	0.000	0.000	7.845	3665.661	1882.000	15664.339

ANNEX B

(*Clause* 5.2.2.2)

AREA INCREMENT METHOD

B-1 DATA

Data given is the same as in **A-1.1**

B-2 PROCEDURE

B-2.1 Table 3 gives typical calculations of an example for working out the revised capacity by using area increment method. The procedure is given below. The data given in column 1, 2 and 3 are from original elevation area capacity curves.

Step 1 — Assume ho, that is, depth in metres to which the reservoir is completely filled with sediment, and corresponding to this ho, read Ao and Vo from the original elevation area capacity curve. Substitute the values in the basic equation Vs = Ao (H - ho) + Vo. Say ho = 12.2 meters, Ao = 124.966 hectares, Vo = 519.20 hectare metres, H = 37.5 metres. Vs is calculated, which comes to 3 680.84 hectare metres which is nearly equal to the 3 700.00 hectare metres of total sediment load within one percent. If it is not, a new zero elevation is assumed till Vs is within one percent of the total sediment load.

Step 2 — Compute the sediment area at different elevations (column 4 in Table 3). The sediment area below new zero-elevation is equal to the original area from the elevation area capacity curve, while that above new zero elevation is equal to the Ao value as computed in step 1.

Step 3 — The incremental volume of sediment (column 5) between two elevations above the assumed new zero elevation is computed by multiplying the sediment area (column 4) by the elevation difference of Table 3. The cumulative sediment volume (column 6) at every elevation is then computed, using the incremental sediment volume.

Step 4 — Revised areas in column 7 are obtained by reducing the original area at each increment in column 2 by the area correction factor in column 4.

Step 5 — The revised capacity is determined by reducing the original capacity at each increment by sediment accumulation (column 8 = column 3 – column 6)

B-2.2 The result obtained should be compared with actual resurvey curve. After verifying, the probable sediment deposition in the reservoir at different depths may be worked out for the sediment volume to be distributed in the period equal to the life of the reservoir.

Table 3 Sediment Deposition Computation by Area Increment Method

(*Clause* B-2.1)

Elevation (m)	Original		Ao (Ha)	Incremental sediment volume (Ha. m)	Cum. Sediment Volume (Ha m)	Revised	
	Area (Ha)	Cum. Capacity (Ha. m)				Area (Ha)	Capacity (Ha. m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1265	0	0	0	—	0	0	0
1266	1.43	0.54	1.43	—	0.54	0	0
1267	4.6	3.43	4.6	—	3.43	0	0
1268	9.23	10.23	9.23	—	10.23	0	0
1269	15.28	22.37	15.28	—	22.37	0	0
1270	22.75	41.26	22.75	—	41.26	0	0
1271	31.7	68.36	31.7	—	68.36	0	0
1272	42.19	105.17	42.19	—	105.17	0	0
1273	54.29	153.27	54.29	—	153.27	0	0
1274	68.08	214.3	68.08	—	214.3	0	0
1275	83.66	290.01	83.66	—	290.01	0	0
1276	101.15	382.24	101.15	—	382.24	0	0
1277	120.64	492.95	120.64	—	492.95	0	0
1277.20	124.97	519.20	124.966	0.000	519.20	0	0
1278	142.27	624.21	124.966	99.973	619.17	17.30	5.04
1279	166.17	778.22	124.966	124.966	744.14	41.20	34.08
1280	192.48	957.32	124.966	124.966	869.11	67.51	88.21
1281	221.35	1163.99	124.966	124.966	994.07	96.38	169.92
1282	252.93	1400.87	124.966	124.966	1119.04	127.96	281.83
1283	287.4	1670.76	124.966	124.966	1244.00	162.43	426.76
1284	324.94	1976.64	124.966	124.966	1368.97	199.97	607.67
1285	365.74	2321.66	124.966	124.966	1493.94	240.77	827.72
1286	410	2709.2	124.966	124.966	1618.90	285.03	1090.30
1287	457.94	3142.81	124.966	124.966	1743.87	332.97	1398.94
1288	509.78	3626.29	124.966	124.966	1868.83	384.81	1757.46
1289	565.77	4163.65	124.966	124.966	1993.80	440.80	2169.85
1290	626.15	4759.17	124.966	124.966	2118.77	501.18	2640.40
1291	691.19	5417.37	124.966	124.966	2243.73	566.22	3173.64
1292	761.19	6143.06	124.966	124.966	2368.70	636.22	3774.36
1293	836.43	6941.34	124.966	124.966	2493.66	711.46	4447.68
1294	917.24	7817.61	124.966	124.966	2618.63	792.27	5198.98
1295	1003.95	8777.6	124.966	124.966	2743.60	878.98	6034.00
1296	1096.92	9827.39	124.966	124.966	2868.56	971.95	6958.83
1297	1196.51	10973.42	124.966	124.966	2993.53	1071.54	7979.89
1298	1303.12	12222.5	124.966	124.966	3118.49	1178.15	9104.01
1299	1417.16	13581.86	124.966	124.966	3243.46	1292.19	10338.40
1300	1539.08	15059.15	124.966	124.966	3368.43	1414.11	11690.72
1301	1669.34	16662.48	124.966	124.966	3493.39	1544.37	13169.09
1302	1808.41	18400.42	124.966	124.966	3618.36	1683.44	14782.06
1302.50	1882	19330	124.966	62.483	3680.84	1757.03	15649.16

ANNEX C

(*Clause* 5.2.3.3)

MOODY'S METHOD TO FIND NEW ZERO ELEVATION

C-1 DATA

Data given is the same as in **A-1.**

C-2 PROCEDURE

C-2.1 Referring to Table 4, the data given in column 1, column 2 and column 3 are taken from the known original elevation area capacity curve. Column 4 is worked out as the result of division of each depth corresponding to the elevation given in column 1 by the total depth (H). Column 5 is obtained by subtracting column 3 from 'S' the total sediment deposit. Column 6 is worked out from the known original area and it is the product of the area at a specified elevation and the total depth. Column 7 is worked out by equation (4). Column 8 is obtained from Fig. 4.

C-2.2 In Fig. 6, f (p) and f'(p) curves are drawn against relative reservoir depth (*p*) and their intersection corresponds to P_o of 0.3271. Therefore, P_oH = 12.27 m and the new zero elevation is 1 265.00 + 12.27 = 1 277.27 m.

Table 4 Moody's Method for Determination of New Zero-Elevation

(*Clause* C-2.1)

Elevation	Area (Ha) A(*p*H)	Capacity (Ha.m) V(*p*H)	Relative depth p	S-V(*p*H)	HA(*p*H)	f'(p) from Eq 4	f(p) from Fig. 4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1265	0	0	0.0000	3700.00			
1266	1.43	0.54	0.0267	3699.46	53.63	68.9876	3.4191
1267	4.6	3.43	0.0533	3696.57	172.50	21.4294	2.1838
1268	9.23	10.23	0.0800	3689.77	346.13	10.6602	1.7902
1269	15.28	22.37	0.1067	3677.63	573.00	6.4182	1.4515
1270	22.75	41.26	0.1333	3658.74	853.13	4.2886	1.2777
1271	31.7	68.36	0.1600	3631.64	1188.75	3.0550	1.1293
1272	42.19	105.17	0.1867	3594.83	1582.13	2.2722	1.0235
1273	54.29	153.27	0.2133	3546.73	2035.88	1.7421	0.9331
1274	68.08	214.3	0.2400	3485.70	2553.00	1.3653	0.8580
1275	83.66	290.01	0.2667	3409.99	3137.25	1.0869	0.7937
1276	101.15	382.24	0.2933	3317.76	3793.13	0.8747	0.7357
1277	120.64	492.95	0.3200	3207.05	4524.00	0.7089	0.6856
1278	142.27	624.21	0.3467	3075.79	5335.13	0.5765	0.6382
1279	166.17	778.22	0.3733	2921.78	6231.38	0.4689	0.5969
1280	192.48	957.32	0.4000	2742.68	7218.00	0.3800	0.5565
1281	221.35	1163.99	0.4267	2536.01	8300.63	0.3055	0.5210
1282	252.93	1400.87	0.4533	2299.13	9484.88	0.2424	0.4860
1283	287.4	1670.76	0.4800	2029.24	10777.50	0.1883	0.4542
1284	324.94	1976.64	0.5067	1723.36	12185.25	0.1414	0.4232
1285	365.74	2321.66	0.5333	1378.34	13715.25	0.1005	0.3946
1286	410	2709.2	0.5600	990.80	15375.00	0.0644	0.3665
1287	457.94	3142.81	0.5867	557.19	17172.75	0.0324	0.3390
1288	509.78	3626.29	0.6133	73.71	19116.75	0.0039	0.3127
1289	565.77	4163.65	0.6400	-463.65	21216.38	-0.0219	0.2875
1290	626.15	4759.17	0.6667	-1059.17	23480.63	-0.0451	0.2631

Table 4 *(Concluded)*

Elevation	Area (Ha) A(*p*H)	Capacity (Ha.m) V(*p*H)	Relative depth p	S-V(*p*H)	HA(*p*H)	f'(p) from Eq 4	f(p) from Fig. 4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1291	691.19	5417.37	0.6933	-1717.37	25919.63	-0.0663	0.2393
1292	761.19	6143.06	0.7200	-2443.06	28544.63	-0.0856	0.2163
1293	836.43	6941.34	0.7467	-3241.34	31366.13	-0.1033	0.1935
1294	917.24	7817.61	0.7733	-4117.61	34396.50	-0.1197	0.1717
1295	1003.95	8777.6	0.8000	-5077.60	37648.13	-0.1349	0.1500
1296	1096.92	9827.39	0.8267	-6127.39	41134.50	-0.1490	0.1290
1297	1196.51	10973.42	0.8533	-7273.42	44869.13	-0.1621	0.1082
1298	1303.12	12222.5	0.8800	-8522.50	48867.00	-0.1744	0.0879
1299	1417.16	13581.86	0.9067	-9881.86	53143.50	-0.1859	0.0667
1300	1539.08	15059.15	0.9333	-11359.15	57715.50	-0.1968	0.0422
1301	1669.34	16662.48	0.9600	-12962.48	62600.25	-0.2071	0.0227
1302	1808.41	18400.42	0.9867	-14700.42	67815.38	-0.2168	0.0095
1302.50	1882	19330	1.0000	-15630.00	70575.00	-0.2215	0.0000

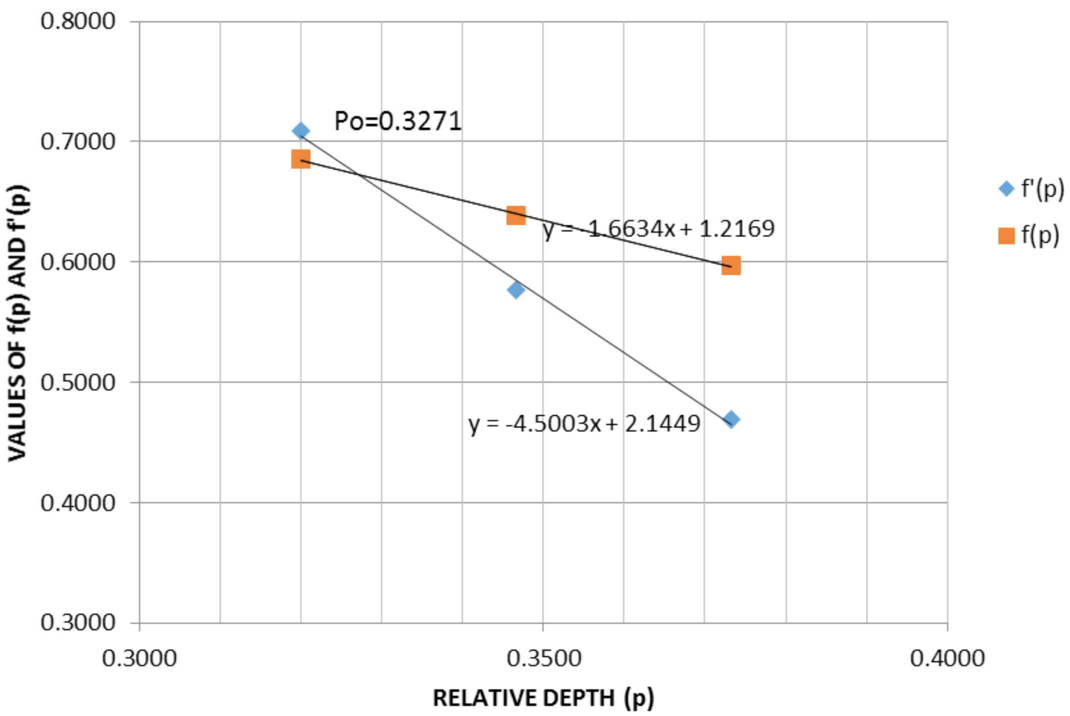

Fig. 6 Example for Direct Determination of New Zero-Elevation

ANNEX D

(*Foreword*)

COMMITTEE COMPOSITION

Composition of Reservoirs and Lakes, Sectional Committee, WRD 10

Organizations	*Representative(s)*
National Institute of Hydrology, Roorkee	Dr Sharad Jain (***Chairman***)
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Irrigation Department, Govt of Punjab, Punjab	Chief Engineer (RSDD) Director Dam (RSDD) (*Alternate*)
Irrigation Deptt. (CDO), Govt of Maharashtra, Maharashtra	Shri Rajendra Pawar Shri Sanjay Lazman Doiphode (*Alternate*)
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This Indian Standard has been developed from Doc No.: WRD 10 (629).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi